3. The Dielectric Constant of Liquids at Microwave Frequencies. (I)

An Experimental Apparatus at 3 cm Wave-Length

Naokazu Koizumi

(Goto Laboratory)

An experimental apparatus for measuring the dielectric constant of liquids at 3 cm wave-length was designed and constructed in the laboratory.

The apparatus consisted of silver plated rectangular wave-guide components whose cross section is 22.9 mm × 10.2 mm I.D., and includes a signal generator, directional couplers, crystal detectors, a liquid cell and a wave meter.

The signal generator was a reflex klystron, type 2K25, fed by an electronically regulated power supply, and its output frequency was monitored by means of a transmission type TE_{011} cavity wave meter which was coupled to the signal generator by a directional coupler.

The liquid cell was a section of wave guide which was surrounded by a constant temperature water jacket, and separated from the remainder of the system by means of a very thin mica sheet clamped between a choke-flange joint. As an opencircuit plunger in the liquid-filled section, a quarter wave-length block of fused quartz was used since its electrical, mechanical and chemical properties was quite suitable for that purpose.

The reflection coefficient Γ at the input plane of liquid varies with an increase in the length of liquid column by withdrawing the plunger.

The variation of Γ, i.e. its amplitude and phase, was observed and recorded by means of a directional coupler and a crystal detector.

Since the wave-length in liquid λ_d was twice the separation between adjacent maxima of $|\Gamma|$ and the dielectric attenuation per wave-length $\alpha_d\lambda_d$ is evaluated from the damping of succesive maxima with the length of liquid, the complex dielectric constant ϵ ($\epsilon=\epsilon'-j\epsilon''$) was culculated by the following equation (W.H. Surfer, Jr.: J. Appl. Phys. **19** 514 (1948)),

$$D=\tan\left[2\tan^{-1}(\alpha_d\lambda_d/2\pi)\right]$$

$$\epsilon'=(\lambda_0/\lambda_c)^2+(\lambda_0/\lambda_d)^2\left[1-\tan^2\left(\frac{1}{2}\tan^{-1}D\right)\right]$$

$$\epsilon=(1/\pi)\,(\lambda_0/\lambda_d)^2\,(\alpha_d\lambda_d),$$

where λ_0 is the free space wave-length, λ_c is the cut off wave-length in the empty guide.